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Model 429/429A/429E

DEFIBRILLATOR ENERGY METER

OPERATING and SERVICE MANUAL

GENERAL ELECTRIC
INSTRUMENTATION & COMMUNICATION
1200 KONA DRIVE
COMPTON, CA 90220
(213) 642-5317

NEURODYNE-DEMPSEY, INC.
2505 Oak Street, Napa, California 94558

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FIGURE 1.1 MODEL 429 DEFIBRILLATOR ENERGY METER

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section I
GENERAL INFORMATION

1.1 ■ INTRODUCTION

1.2 This manual contains operating and maintenance instructions for the Model 429, 429A and 429E DEFIBRILLATOR ENERGY METER.

NOTE

Reference is made to the A and E versions of the Model 429 only when they differ from the original Model 429. The operation and construction of each is similar, the differences being only in range and line voltage.

1.3 ■ DESCRIPTION

1.4 The Model 429 Defibrillator Energy Meter is a precision pulse energy measuring instrument, designed primarily for the purpose of verifying or calibrating the output energy from all DC defibrillators. This instrument is portable, accurate, and easy to use.

The operation of the 429 is almost totally automatic, leaving only the range selection and power switch movements to the user. After these are made, the user places the paddles of the charged defibrillator against the input contact plates. The defibrillator is then discharged into the 429 which gives a reading of the delivered energy into the 50 ohm load. The reading is retained by the 429 for a period of five seconds, allowing the user ample time for observation.

1.5 ■ SPECIFICATIONS

1.6 Specifications for the Model 429 Defibrillator Energy Meter are listed in Table 1-1.

TABLE 1-1 SPECIFICATIONS

POWER RANGES:	
MODEL 429 and 429E;	0-40, 0-100, and 0-400 watt-seconds
MODEL 429A;	0-50, 0-150, and 0-500 watt-seconds
LOAD RESISTANCE:	50 ohm ±0.5%
PULSE WIDTH:	2-30 ms
ACCURACY:	±2% of full scale for pulse width of 2 ms decreasing to ±7% for a pulse width of 20 ms at 20°C
TEMPERATURE RANGE:	15° to 40°C
TEMPERATURE COEFFICIENT:	0.1%/C
LINE VOLTAGE:	
MODEL 429;	115V ±10% 60Hz
MODEL 429A and E;	115/230V ±10% 50-60Hz
OUTPUT JACK:	B.N.C. output jack with 1000:1 ±5% attenuation provided on the rear panel for oscilloscope connection

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section II
INSTALLATION

2.1 ■ INTRODUCTION

2.2 This section contains information on inspection, installation, and repackaging for shipment.

2.3 ■ INCOMING INSPECTION

2.4 This instrument was carefully inspected both mechanically and electrically before shipment. Upon receipt, the instrument should be inspected for physical damage in transit, and the electrical performance should be tested using the procedure outlined in Par. 5.4 of section V, Performance Check and Calibration.

2.5 ■ CLAIMS

2.6 If physical damage is found or if operation is not within specifications when the instrument is received, notify the carrier immediately. Please read the sheet on DAMAGE and SHORTAGE at the back of this book. If Neurodyne-Dempsey, Inc. or their factory representative is notified, arrangements will be made for the repair or replacement of the instrument without waiting for the carrier to settle the claim. If it is desired that damage be repaired prior to the settlement of the claim, a new purchase order must be issued to cover this work.

2.7 ■ WARRANTY REPAIR

2.8 The warranty statement for all Neurodyne-Dempsey, Inc. products is on the back of the title page of this manual.

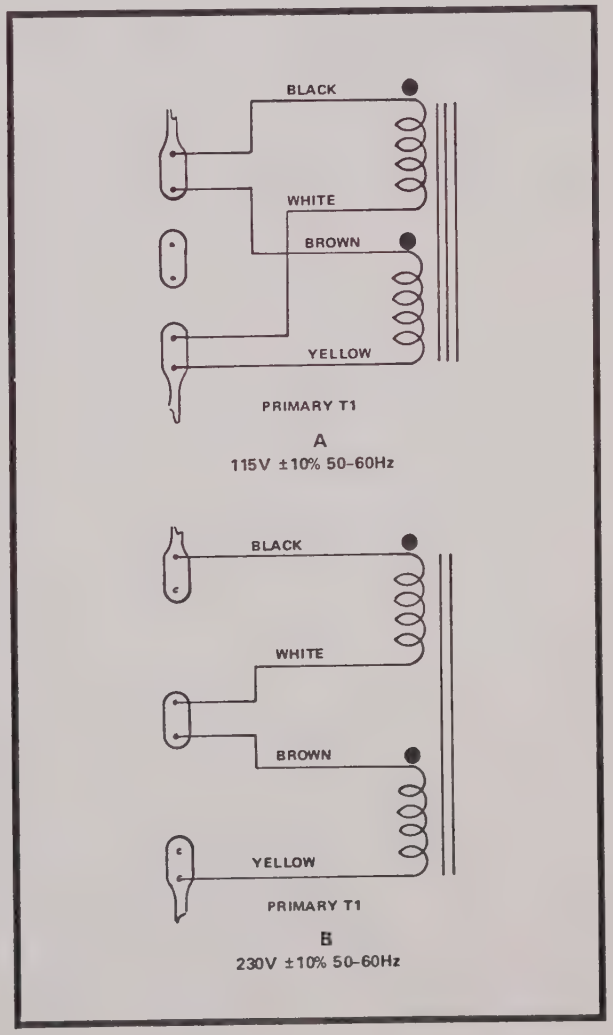
2.9 The warranty does not cover the cost of transportation. No COD shipments will be accepted without prior authorization. All transportation and phone charges will be billed to the customer.

2.10 It is recommended that United Parcel Service or Air Parcel Post be used to return the instrument to the factory. Please follow the guidelines given in Paragraphs 2.12 thru 2.13 when packaging the instrument to avoid further delay or damage.

2.11 ■ REPACKAGING FOR SHIPMENT

2.12 When shipping an instrument to Neurodyne-Dempsey, Inc., attach a tag describing required services and include model number, serial number, and return address.

FIGURE 2.1 STRAPPING FOR LINE VOLTAGE CHANGE



2.13 The following is a general guide for repackaging an instrument for shipment:

a. Place instrument in original containers if available.

b. If original container is not available, use a heavy carton or wooden box as a container and use strong tape or metal bands to seal it.

c. Wrap instrument in heavy paper or plastic before placing in container.

d. Use at least four inches of tightly packed, industry-approved, shock-absorbing material around the instrument.

e. Mark the shipping container "Delicate Instrument," "Fragile," etc.

2.14 ■ INSTALLATIONS

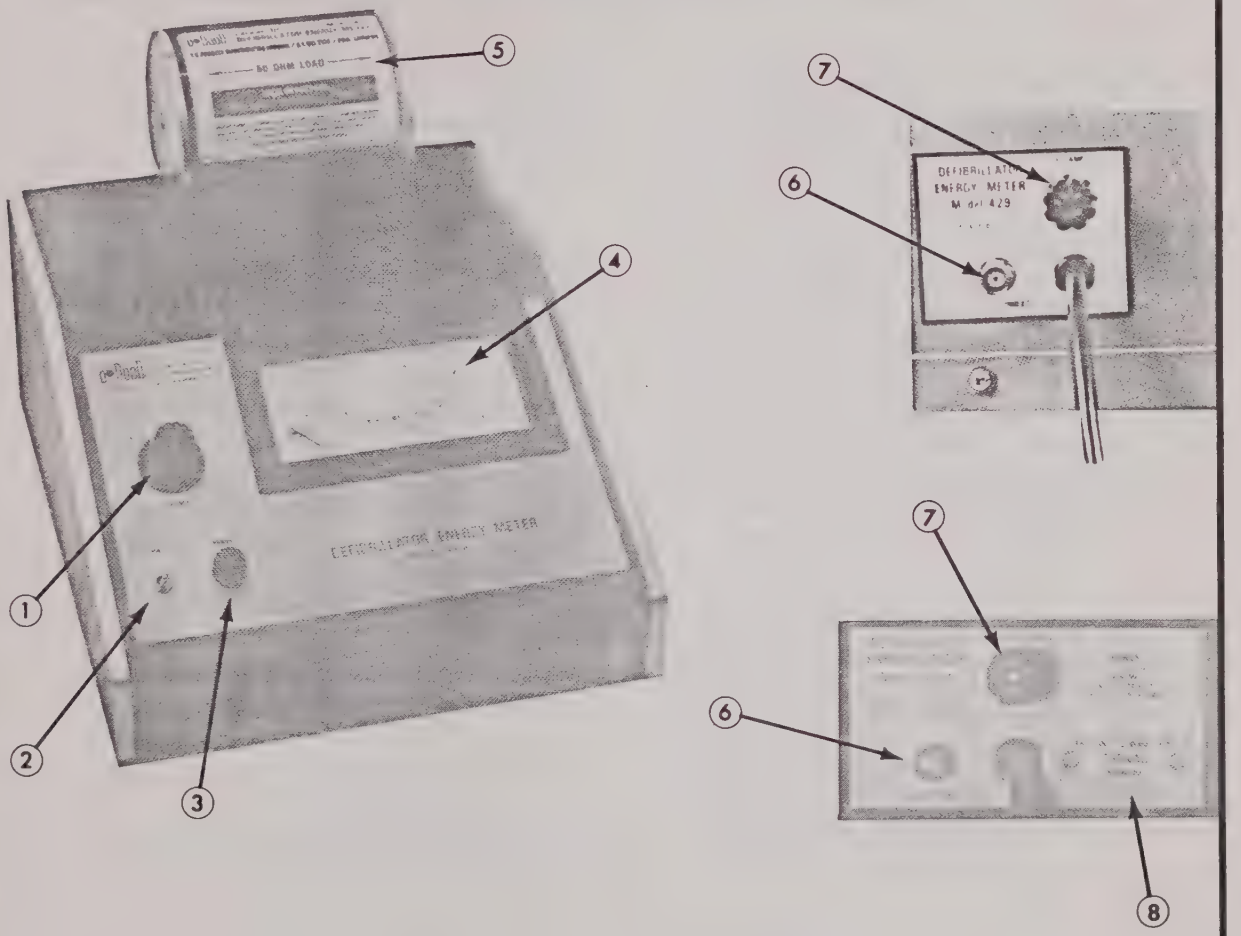
2.15 The Model 429 is a complete instrument and is ready to use upon connection to the 115V ±10% 60Hz power source.

2.16 The Model 429A can be operated on 115/230V ±10% 50-60Hz power and is shipped wired for 115V. See Paragraph 2.19 to change the wiring for 230V operation.

2.17 The Model 429E can be operated on 115/230V ±10% 50-60Hz power and is shipped wired for 230V. See Paragraph 2.19 to change the wiring for 115V operation.

2.18 ■ 115/230V OPERATION OF 429A AND 429E

2.19 For operation of the Model 429A and E from 115V power, the primary of the transformer T1 located on the PC board is connected as shown in Figure 2.1A. For operation from 230V line, connect the primary leads as shown in Figure 2.1B. On Model 429A, orient line voltage tag to reflect the proper operating voltage.



1.	RANGE SELECTOR	Selects the desired meter range.
2.	POWER ON/OFF SWITCH	Turns instrument power on.
3.	POWER ON INDICATOR	Lights when power is applied.
4.	METER	Indicates the amount of energy delivered to the load.
5.	50 OHM LOAD	Provides contacts for defibrillator paddles.
6.	SCOPE OUTPUT JACK	Provides 1000:1 attenuation of defibrillator pulse.
7.	FUSE	Provides fault protection for instrument.
8.	VOLTAGE TAG	Indicates line voltage equipment is wired to operate on.

FIGURE 3.1 FRONT AND REAR PANEL CONTROLS AND FUNCTIONS

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section III
OPERATION

3.1 ■ INTRODUCTION

3.2 This section contains information on the operation of the Model 429. It assumes that the unit is operating correctly.

3.3 ■ CONTROLS

3.4 Front panel controls, indicator and rear panel functions are described in Figure 3.1.

3.5 To measure the output of a defibrillator proceed as follows:

a. Connect the Model 429 and the defibrillator to a source of power and turn the unit on.

b. Adjust the output of the defibrillator to the desired setting following the manufacturers recommendations.

c. Select a range on the Model 429 that corresponds to the output level selected on the defibrillator.

d. Place the defibrillator paddles firmly against the end caps on the load and discharge the defibrillator.

e. Read the energy dissipated in the 50 ohm load on the meter of the Model 429.

3.6 To observe the voltage wave form, connect an oscilloscope to the SCOPE OUT jack on the rear of the 429. Set the sweep speed to 1 ms/div. and the vertical gain to 0.5V/div., set the oscilloscope to the triggered mode and discharge the defibrillator into the 50 ohm load on the 429.

NOTE

This attenuator is not frequency compensated so the high frequency voltage division is not as great as the low frequency voltage division.

NOTE

Some defibrillators have one of their output leads connected to the chassis (ground). If the paddle that is grounded is connected to the right side of the load on the 429, no output will appear at the SCOPE OUT jack. In this case, reversing the paddles will cause the output to be present.

3.7 Some defibrillators use a transformer in their output. A transformer cannot transfer DC, and as a result, when these defibrillators are discharged, they produce a reverse current that lasts for several seconds when they are connected to the 50 ohm load. If the paddles are removed from the load, a high level RF signal is generated which might affect the reading of the 429 at the high energy levels. If it is determined that this is happening, the paddles should be left in contact with the load until the reading is taken.

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section IV

PRINCIPLES of OPERATION

4.1 ■ GENERAL

4.2 This section contains information on the energy contained in a pulse, one method of measuring this energy, and the circuits used in the Model 429.

4.3 ■ ENERGY CONTENT OF A PULSE

4.4 The energy contained in a pulse of arbitrary shape and time duration (Figure 4.1) is given by:

$$W = \int_0^T e(t)\ i(t)\ dt$$

where W is the energy in watt-seconds

$e(t)$ is the voltage as a function of time

$i(t)$ is the current as a function of time

and T is the time duration of the pulse

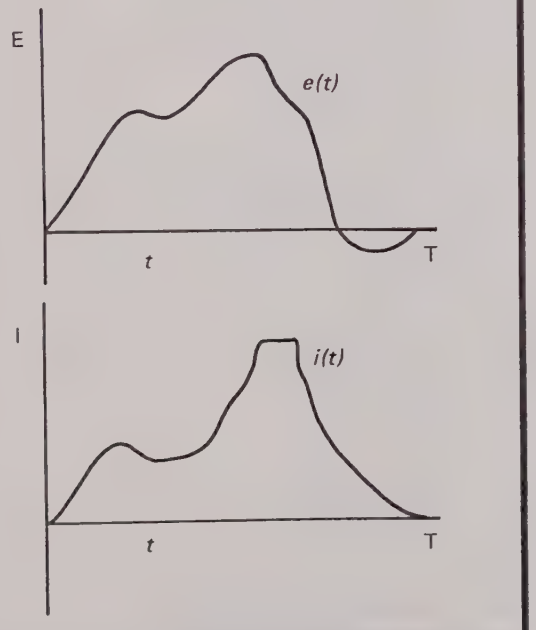

FIGURE 4.1 PULSE OF ARBITRARY SHAPE AND TIME

4.5 For the special case where the voltage exists across a constant resistance the energy dissipated in that resistance reduces to:

$$W = \frac{1}{R} \int_0^T e(t)^2 \quad dt$$

where R is the resistance of the load

4.6 Thus, in order to measure the energy dissipated in a known resistive load from a pulse, first square the voltage and then integrate the resulting functions for the duration of the pulse. This is shown in block diagram form in Figure 4.2 and is basically how the Model 429 operates.

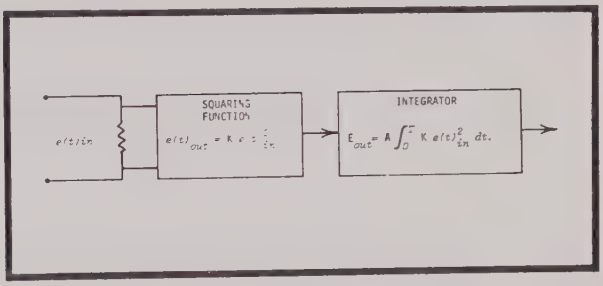

FIGURE 4.2 BLOCK DIAGRAM OF BASIC CONCEPT

4.7 ■ OPERATION OF MODEL 429

4.8 A block diagram of the 429 is shown in Figure 4.3 and a description of the circuits are given in the following paragraphs.

4.9 The Model 429 contains 13 major circuits which are: the 50 ohm load, attenuators and range selector, squaring circuit, pulse detector, main sequence multivibrator, sample time multivibrator, sample switch AND gate, sample switch, pulse integrator, energy indicator, reset switch, display time generator, and the power supplies. These circuits perform the various functions necessary for the unit to operate.

4.10 50 OHM LOAD

4.11 The 50 ohm load is the standard into which the de-

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fibrillator is discharged so the energy can be computed.

4.12 ATTENUATORS AND RANGE SELECTOR

4.13 This circuit scales the voltage amplitude down to provide a sample for the oscilloscope output and the squaring circuit.

4.14 SQUARING CIRCUIT

4.15 The squaring circuit generates the square of the sample voltage. This is the true square and the unit has excellent linearity.

4.16 PULSE DETECTOR

4.17 The pulse detector monitors the output of the squaring function; when the amplitude exceeds a fixed level, it initiates the operation of the main sequence multivibrator.

4.18 MAIN SEQUENCE MULTIVIBRATOR

4.19 This circuit simultaneously starts the sample time multivibrator and display time generator, and turns off the reset switch. After the start of the sequence, this circuit prevents the reading from being changed by the application of a second pulse before the display time generator has completed its operation.

4.20 SAMPLE TIME MULTIVIBRATOR

4.21 This circuit controls the time that the sample switch can be turned on, if an output is present from the pulse integrator. This in turn controls the maximum pulse width the unit will measure.

4.22 SAMPLE SWITCH AND GATE

4.23 This circuit turns the sample switch on only when there is a signal present from the sample time multivibrator and the pulse detector. The function of this circuit is to minimize the effect on the output due to the zero offset of the multiplier.

4.24 SAMPLE SWITCH

4.25 The sample switch connects the integrator to the squaring circuit only after it is determined that a pulse

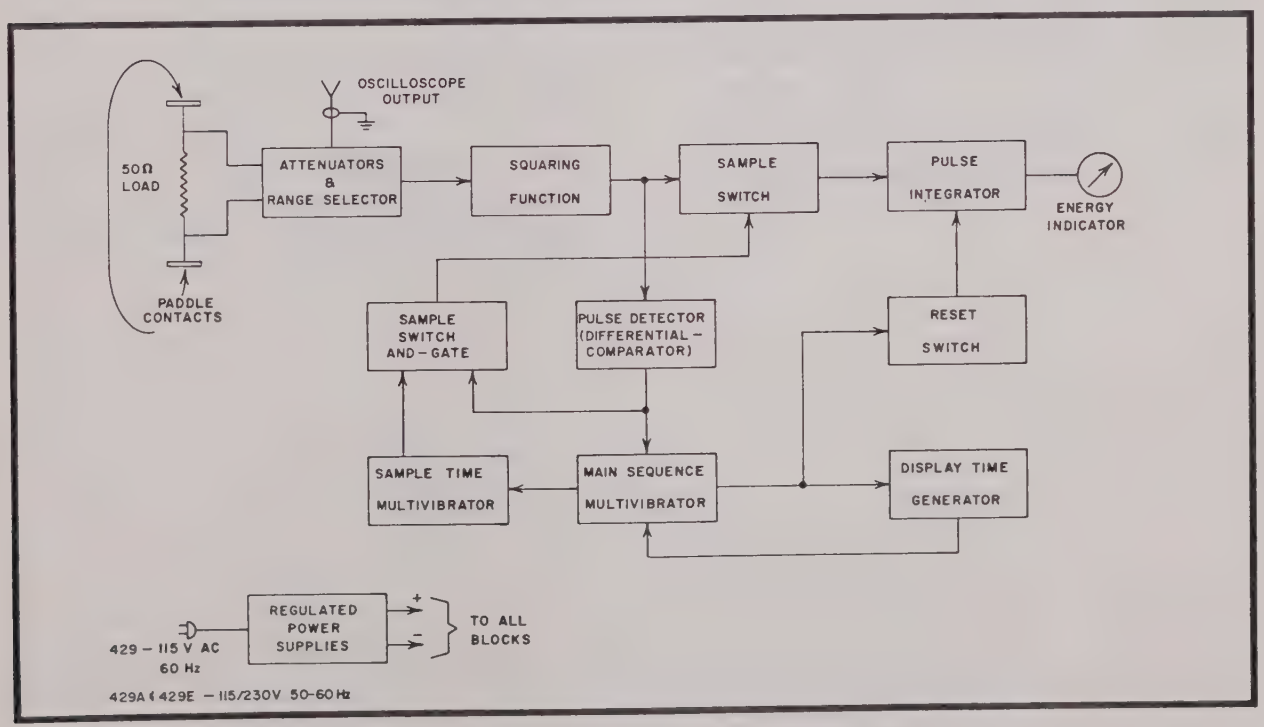

FIGURE 4.3 BLOCK DIAGRAM OF MODEL 429

is present, and then only during the sample time when a pulse is present. This allows the integrator to be used as an analog storage element as well.

4.26 PULSE INTEGRATOR

4.27 This circuit integrates the squared function pulse during the time the sample gate is closed; during the remainder of the display time it acts as an analog storage element.

4.28 ENERGY INDICATOR

4.29 The analog meter indicates the voltage stored in the pulse integrator and is calibrated in watt-seconds.

4.30 RESET SWITCH

4.31 When the reset switch is turned off (during the display time) the integrator can integrate the pulse and act as a storage element. When it is turned on, it resets the integrator to zero in preparation for the next pulse.

4.32 DISPLAY TIME GENERATOR

4.33 The display time generator controls the length of time the reading is displayed on the meter.

4.34 POWER SUPPLY

4.35 The power supply provides +15V and -15V DC to operate the circuitry.

4.36 ■ DETAILED CIRCUIT DESCRIPTION

4.37 Most of the circuits used in the instrument are well understood and will not be discussed further; however, the squaring circuit and the FET in the +15V power supply are unique and will be discussed further.

4.38 SQUARING CIRCUIT

4.39 The squaring circuit consists of a four-quadrant multiplier (A1) and an operational amplifier (A2).

4.40 The four-quadrant multiplier is a linear monolithic circuit which operates on the principle of variable transconductance. The output of this unit is a current that is proportional to the product of the two inputs. In the squaring mode the two inputs X and Y are tied together so the output current is proportional to X^2.

4.41 The operational amplifier operates as a current-to-voltage converter producing a voltage that is proportional to the output current from the multiplier. The gain is adjusted so that the output is one tenth of X^2.

4.42 POWER SUPPLY FET

4.43 The power supply regulator is a conventional series pass type except for the use of the FET to drive the series pass transistor. By using a Junction FET the gate can be supplied from the regulated voltage instead of from the unregulated voltage as in the normal case. Also, since the gate current is extremly low, the collector resistor of the differential amplifier can be made large for maximum voltage gain. These two advantages allow a single stage of amplification to achieve good regulation and line rejection.

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section V

MAINTENANCE and CALIBRATION

5.1 ■ GENERAL

5.2 This section contains information for the maintenance and calibration of the Model 429.

5.3 The Model 429 is all solid state and should need no periodic maintenance except cleaning the case and calibrating the instrument.

5.4 A quick check of the 429 can be made by the following method: Select the middle range on the 429*. Set the output of a defibrillator to a point near 100 watt-seconds. Allow 20 seconds for the defibrillator to reach full charge. Discharge the defibrillator into the 429 and note the reading. Recharge the defibrillator at the same setting and allow another 20 seconds to reach full charge. Reverse the paddles on the load of the 429 and discharge the defibrillator. The two readings should be within 2% of each other. If the readings do agree, the 429 is functioning correctly.

NOTE

This does not check the calibration of the Model 429.

5.5 ■ CALIBRATION

5.6 Calibration of the Model 429 is straightforward and can be done in a laboratory that is set up for calibration work. To simplify the calibration of the unit, the Model 430 Pulse Calibrator, which incorporates several test equipment functions into one unit, is recommended.

5.7 The test equipment required is listed in Table 5-2.

5.8 To calibrate the Model 429, remove the two screws on the rear of the unit and slide the bottom panel out. Set the unit up-side-down on a protective mat and warm up the unit and the test equipment for about 10 minutes.

TABLE 5-1 CHARACTERISTICS OF MODEL 430 PULSE CALIBRATOR

(CAL OUT) OUTPUT		
DC,	VOLTAGE:	Amplitude adjustable between +11.99V and -11.99V in 0.01V increments.
	CURRENT:	10ma.
	ACCURACY:	±0.1% of full scale.
	TEMPERATURE COEFFICIENT:	±0.01%/°C.
PULSE,	AMPLITUDE:	Same as DC setting.
	PULSE WIDTH:	2ms and 10ms internal. External pulse width input.
	ACCURACY:	Amplitude, all specifications same as DC.
	Pulse Width:	±0.1% internal.
	Temperature Coefficient:	±0.02% / °C.
	RISE and FALL TIME:	Less then 1μ sec.
	PULSE REP RATE:	Manual or internal.
	INTERNAL RATE:	10 to 60 pulses per minute.

*100 watt-seconds on the 429 and 429E, 150 watt-seconds on the 429A.

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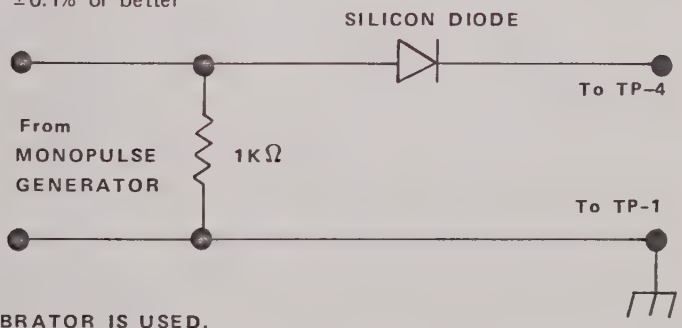
TABLE 5-2 TEST EQUIPMENT REQUIRED TO CALIBRATE THE MODEL 429

EQUIPMENT	CHARACTERISTIC	TYPICAL
MODEL 430	As listed in Table 5-1	Neurodyne-Dempsey, Inc.
VARIABLE TRANSFORMER	1 amp capacity	Superior Electric, Model 2PF10
DIGITAL VOLTMETER	4 digit capable of measuring 10V with 1 mv resolution and 0.1% accuracy, or better	HP, Model 3440 A
MONOPULSE GENERATOR*	Capable of supplying one positive going pulse of 2 ms duration and 10V amplitude upon command	Wavetek, Model 116
OSCILLOSCOPE	0.5 second per division ± 10% or better	Tektronic 545
REFERENCE POWER SUPPLY*	Provide adjustable output between ±10V settable within ±0.1% or better	HP, Model 740 B
TEST NETWORK*		

* NOT NEEDED IF MODEL 430 CALIBRATOR IS USED.

5.9 ■ POWER SUPPLY ADJUSTMENT

5.10 Connect the DVM common to TP-1 and the other lead to TP-3 (see Fig. 5.2 and 5.3 for test point location). The DVM should read between -15.1 and -15.0 volts. Adjust R8 until the output is within this range. Move the DVM HI lead to TP-2. This voltage should be positive and the same magnitude as TP-3 within ±1% (±0.15 volts).

5.11 Plug the 429 into the variable transformer, adjust the transformer from 105 to 130V AC or 210 to 260V AC as appropriate, and note that the voltage at TP-2 does not change.

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5.12 ■ SQUARING CIRCUIT ALIGNMENT

5.13 The alignment of the squaring circuit can be performed using the following procedure.

a. Connect the HI side of the DVM to TP-5, and the LOW side to TP-1. Set the range switch on the Model 429 under test to 100 watt-seconds (150 watt-seconds on the 429A). Connect the output of the reference DC supply (or Model 430) between TP-1 and TP-4, LOW to TP-1 and HI to TP-4.

b. Set the output of the reference supply (or Model 430) to zero.

c. Adjust R24 until the voltage at TP-5 is 0.000V ±0.010V DC.

d. Set the reference supply (or Model 430) to +10.00V DC.

e. Adjust R25 until the voltage at TP-5 is -10.00V DC.

f. Set the reference supply (or Model 430) to -10.00V DC. The voltage measured at TP-5 should be equal to the voltage when +10.00V DC is applied at TP-4. If the two voltages are not equal adjust R23 until they are equal.

g. The three adjustments R24, R25 and R23 are interreacting and the procedure b through e should be performed until all readings are within 10 mv of their nominal values.

h. Check the linearity of the squaring circuit by applying the voltages in Table 5-3 to TP-4 and reading the voltage at TP-5. The linearity should be within ±0.5% of full scale (±0.050V) and typically within ±0.2%.

i. If the squaring circuit does not fall within the ±0.5% linearity, another high adjusting point may be tried, e.g: TP-4 9.000V and TP-5 8.100 volts and steps a through h repeated.

5.14 ■ INTEGRATOR ADJUSTMENT

5.15 Connect the output of the pulse generator (or Model 430) through the test network if needed to TP-4. Adjust the generator to produce a 2 ms pulse at about 5V amplitude, at the output of the test network.

TABLE 5-3 INPUT-OUTPUT VOLTAGE FOR SQUARING CIRCUIT

INPUT VOLTAGE Between TP-4 and TP-1	OUTPUT VOLTAGE Between TP-5 and TP-1
± 10.000	- 10.000
± 9.000	- 8.100
± 8.000	- 6.400
± 7.000	- 4.900
± 6.000	- 3.600
± 5.000	- 2.500
± 4.000	- 1.600
± 3.000	- 0.900
± 2.000	- 0.400
± 1.000	- 0.100
0.000	0.000

NOTE

The test network will be needed if the output of the pulse generator has a DC offset.

5.16 Turn the Model 429 under test right-side-up and fire the pulse generator. Using the meter as an indicator, adjust R36 for minimum drift.

5.17 Set the width of the pulse generator to 2.000 ms ±0.1% and the output to 10.00V ±0.1% at the output of the test circuit when it is connected to the 429. Fire the pulse generator and adjust R26 until the meter indicates 100 watt-seconds (150 watt-seconds on the 429A).

NOTE

This adjustment will have to be made by noting which way the reading is off. Adjust R26 a small amount, then fire the pulse generator and note the reading again, etc.

5.18 After the adjustment has been completed, check the output at various points to check the readout tracking of the meter (see Table 5-4 or 5-5 for input-output voltages).

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TABLE 5-4 METER READINGS FOR VARIOUS PULSE WIDTHS, MODEL 429&429E

METER READING WATT-SECONDS	Input Voltage for each pulse width	
	2 ms	10 ms
100	±10.000	± 4.472
90	± 9.487	± 4.242
80	± 8.945	± 4.000
70	± 8.367	± 3.741
60	± 7.746	± 3.464
50	± 7.071	± 3.162
40	± 6.325	± 2.828
30	± 5.478	± 2.449
20	± 4.473	± 2.000
10	± 3.163	± 1.414
0	0	0

TABLE 5-5 METER READINGS FOR VARIOUS PULSE WIDTHS, MODEL 429A

METER READING WATT-SECONDS	Input Voltage for each pulse width	
	2 ms	10 ms
150	±10.000	± 4.472
140	± 9.661	± 4.320
130	± 9.309	± 4.163
120	± 8.944	± 4.000
110	± 8.563	± 3.830
100	± 8.165	± 3.651
90	± 7.746	± 3.464
80	± 7.303	± 3.266
70	± 6.831	± 3.055
60	± 6.324	± 2.828
50	± 5.774	± 2.582
40	± 5.164	± 2.309
30	± 4.472	± 2.000
20	± 3.651	± 1.633
10	± 2.582	± 1.155
0	0	0

5.19 ■ DISPLAY TIME ADJUSTMENT

5.20 Connect an oscilloscope to TP-10 and set the oscilloscope up to be triggered by the pulse generator. Set the sweep speed to 1 sec. per div. Fire the pulse generator and measure the time the reset pulse occurs. Adjust R51 until this time is 5 sec. ±10%.

5.21 This completes the calibration of the Model 429 Defibrillator Energy Meter.

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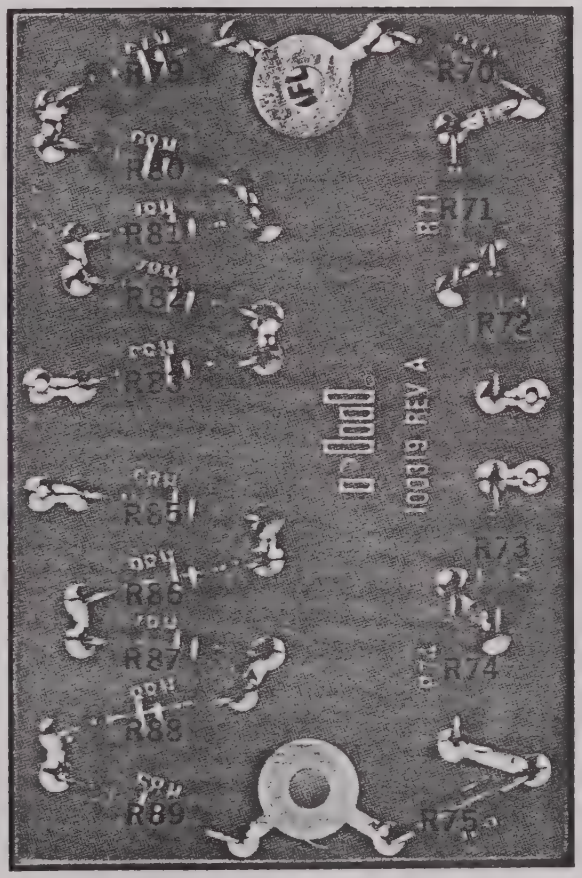

FIGURE 5.1 LOAD PC BOARD COMPONENT LOCATION

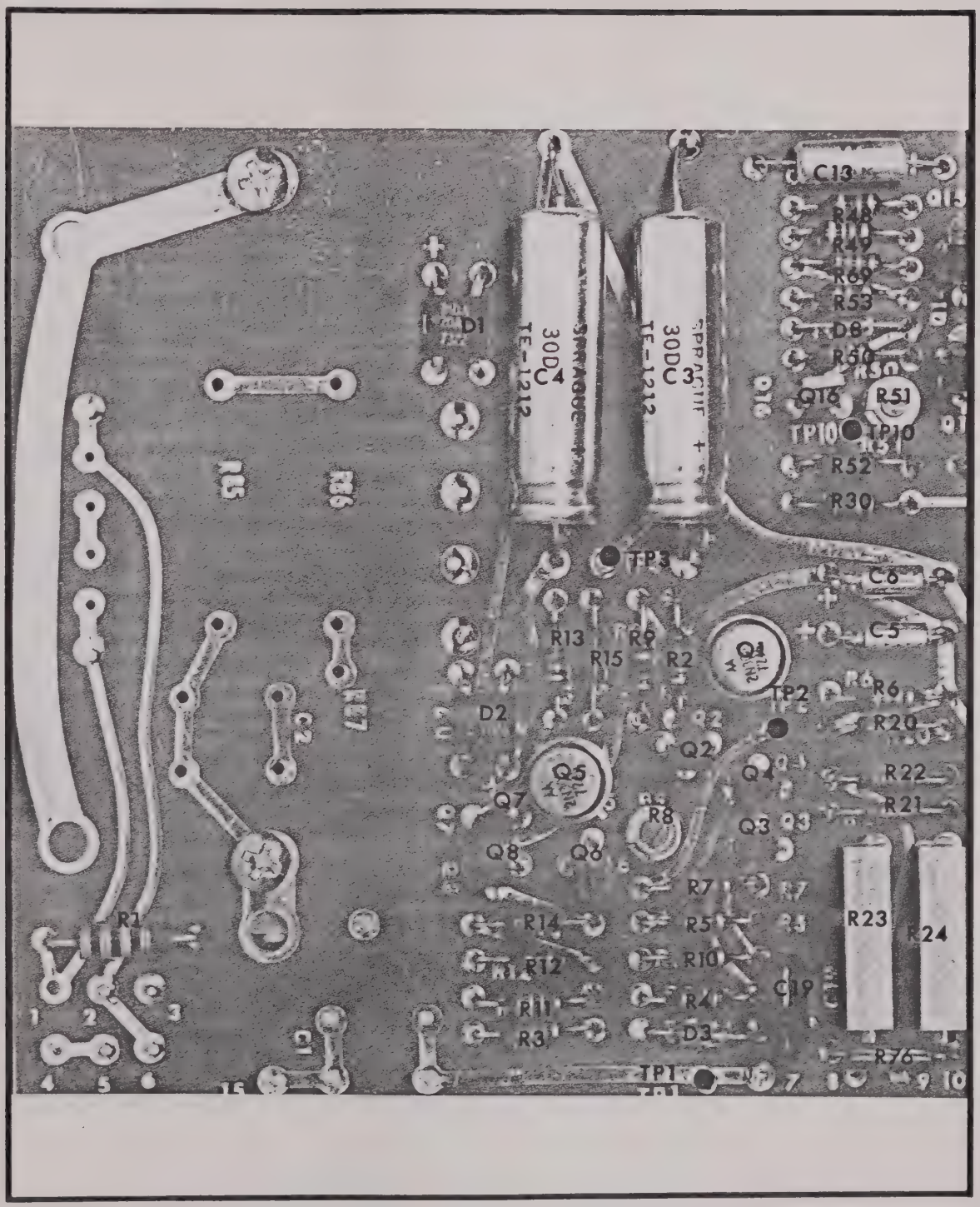

FIGURE 5.2 MAIN PC BOARD COMPONENT LOCATION

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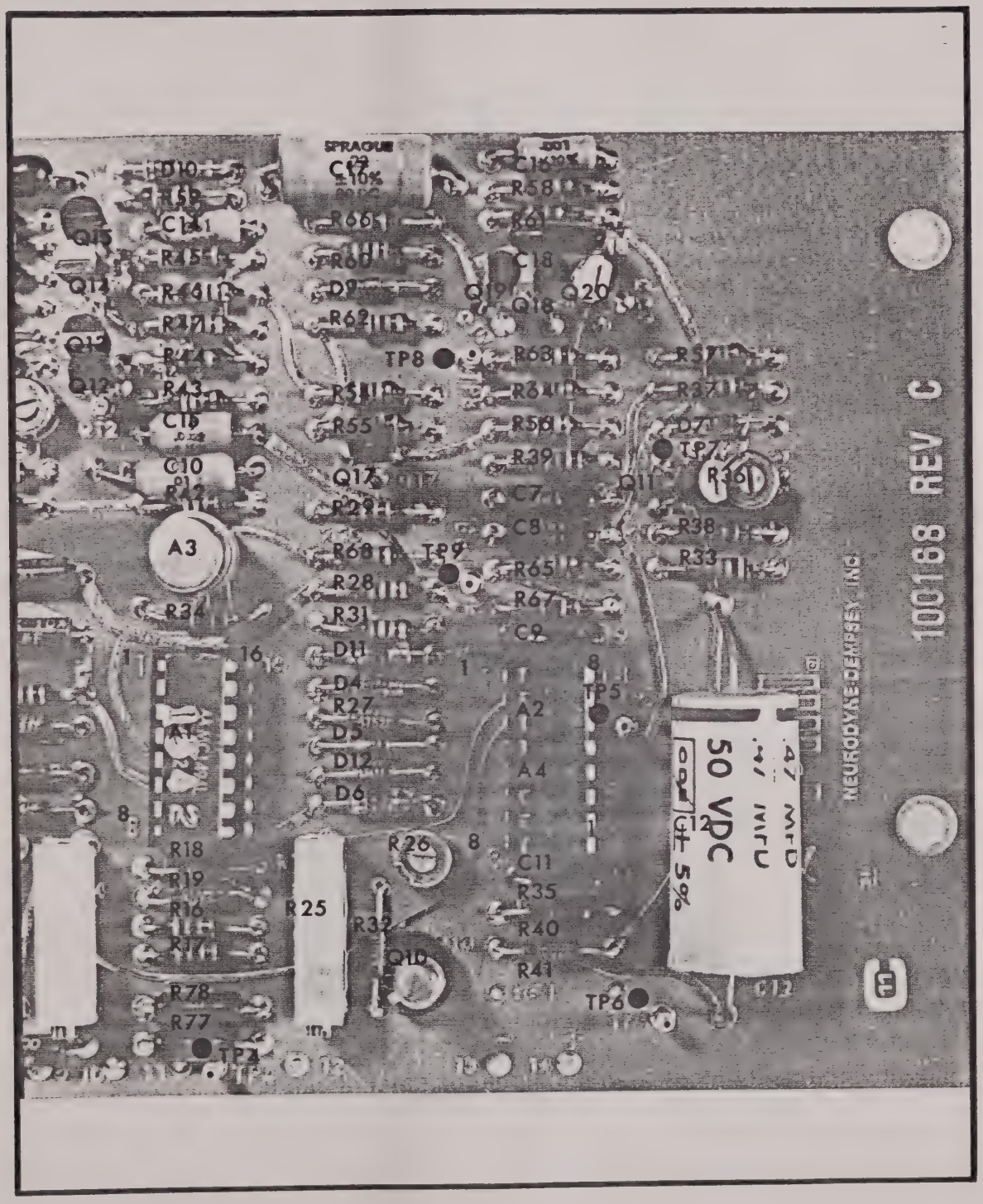
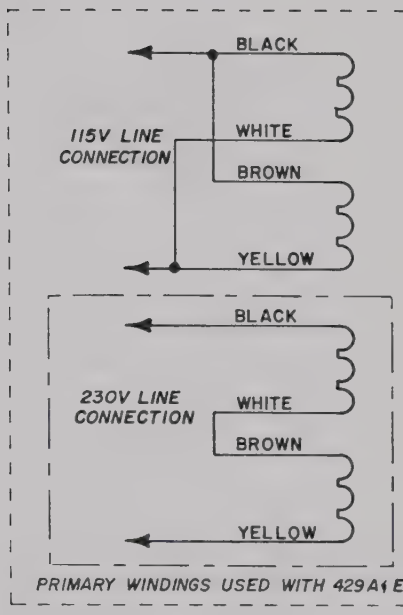
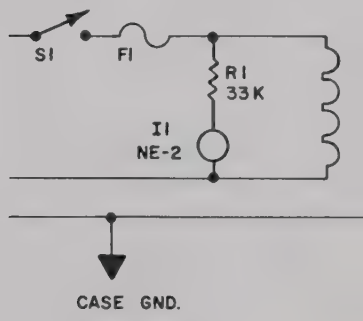
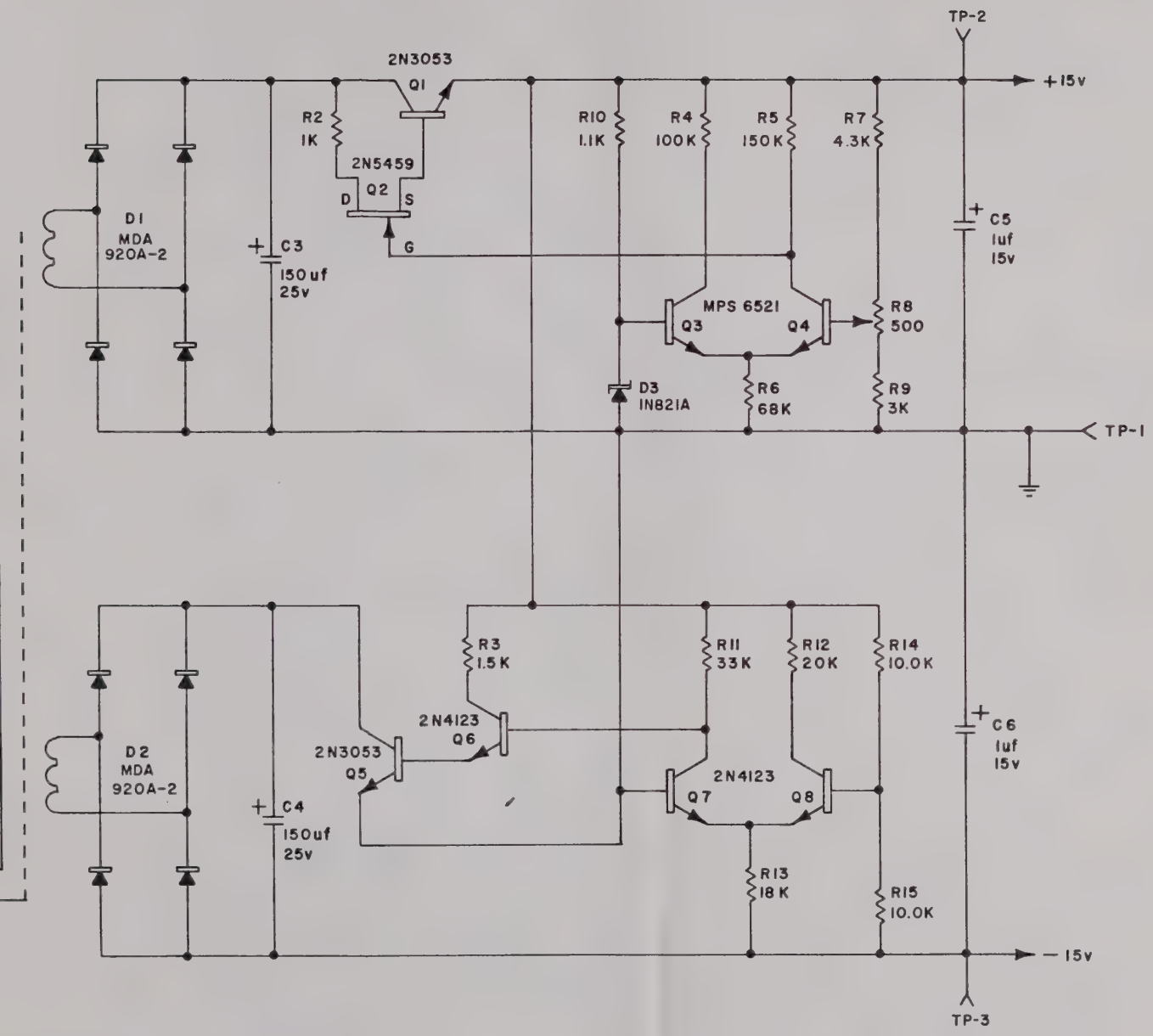






NOTE

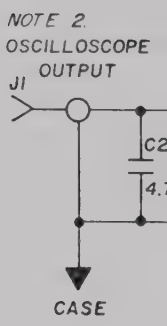
(1) ALL RESISTORS
ARE ±5%, THRE



TH TWO DIGITS
IGITS ±1%

POWER SUPPLY SCHEMATIC

FIGURE 5.3 POWER SUPPLY SCHEMATIC



NOTES:

1. FACING
2. ATTENUA
3. RESISTO
4. EARLIER
   R84 WAS
5. VALUES S
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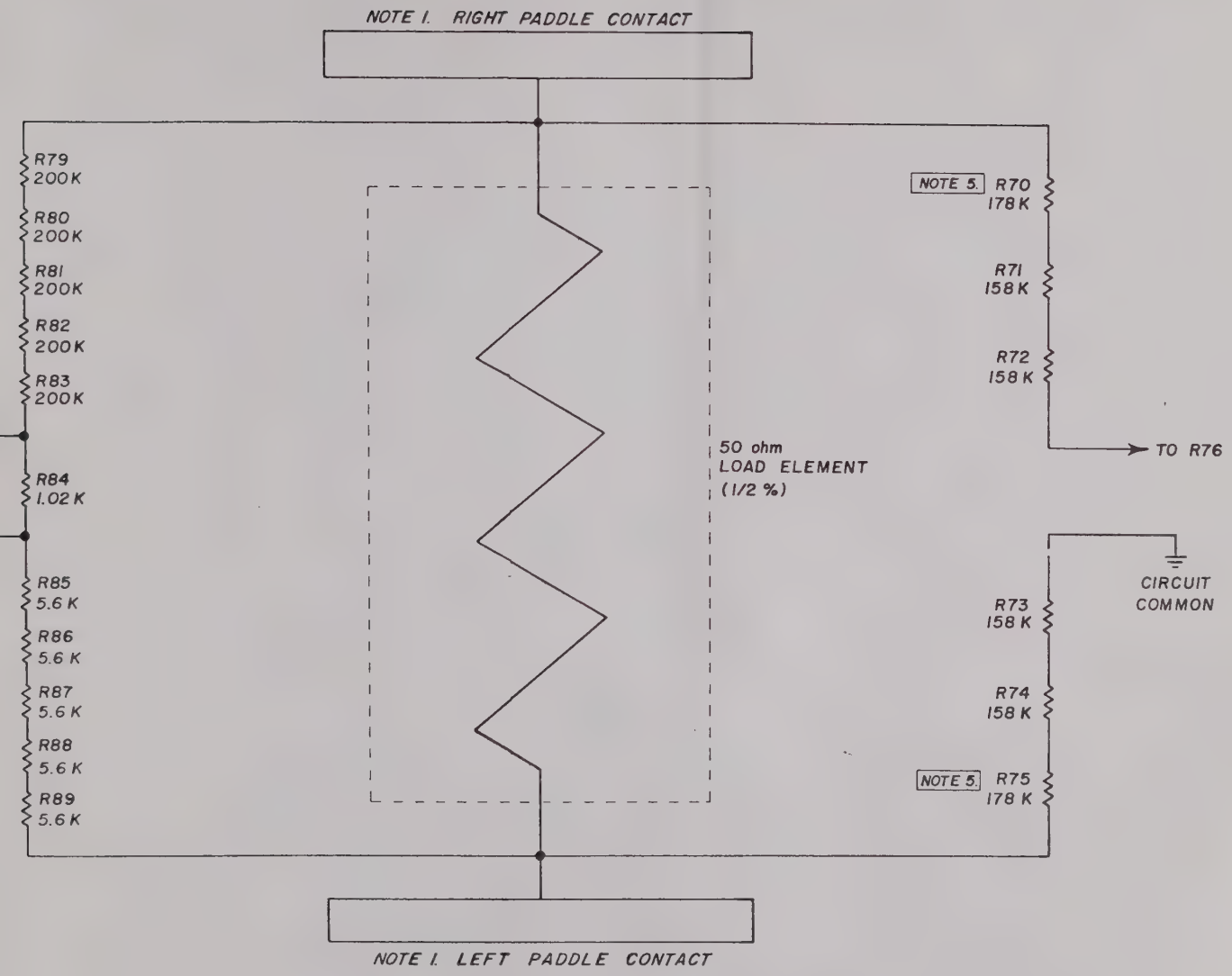
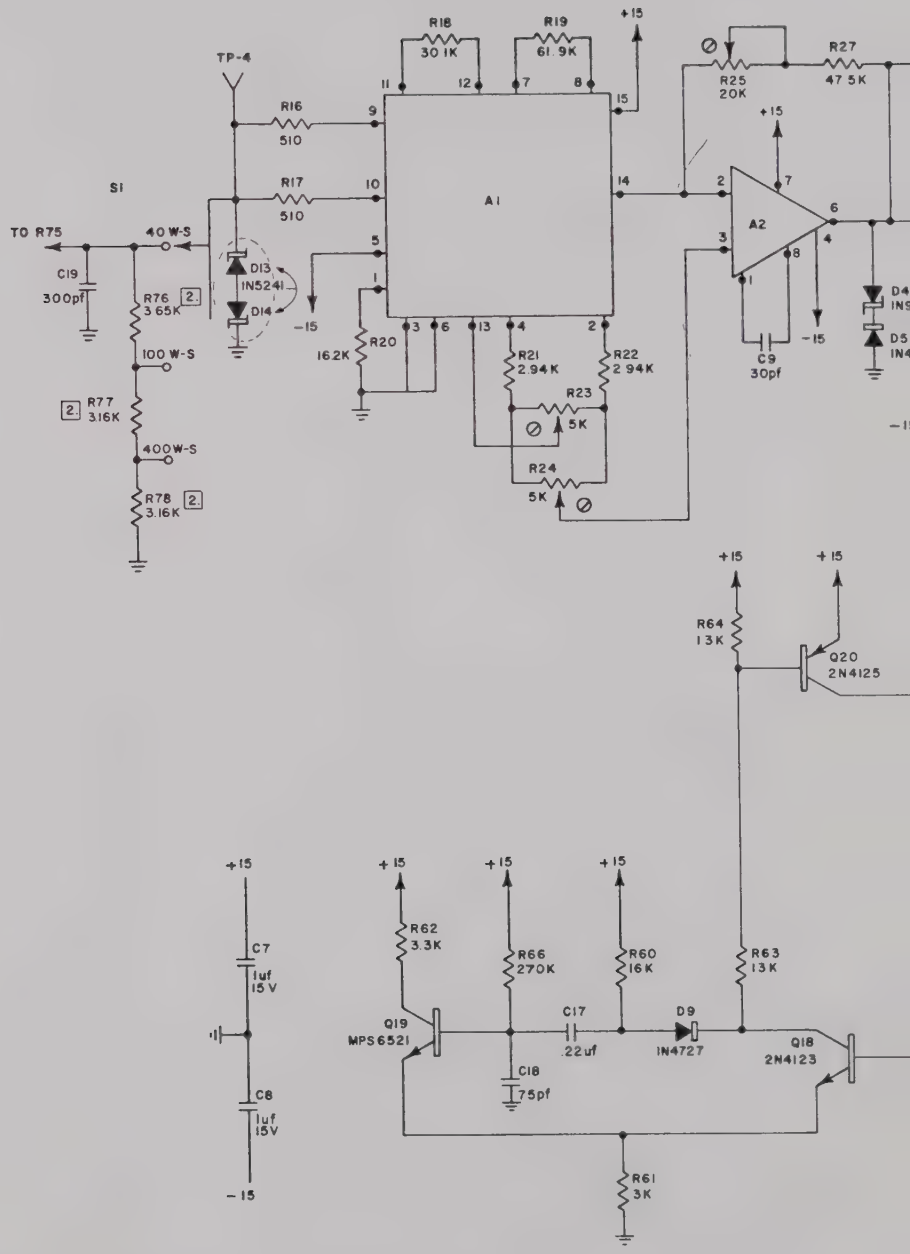


LOAD and ATTENUATORS

ONT PANEL.
N 1000:1 5%
WITH 3 DIGITS ARE ±1% OTHERS ARE ±5%
TS VALUES OF R85 — R89 WHERE 200K.
AND C20 WAS 2.2nf.
VN ARE FOR MODEL 429 AND 429E.
29A VALUE IS 174K.

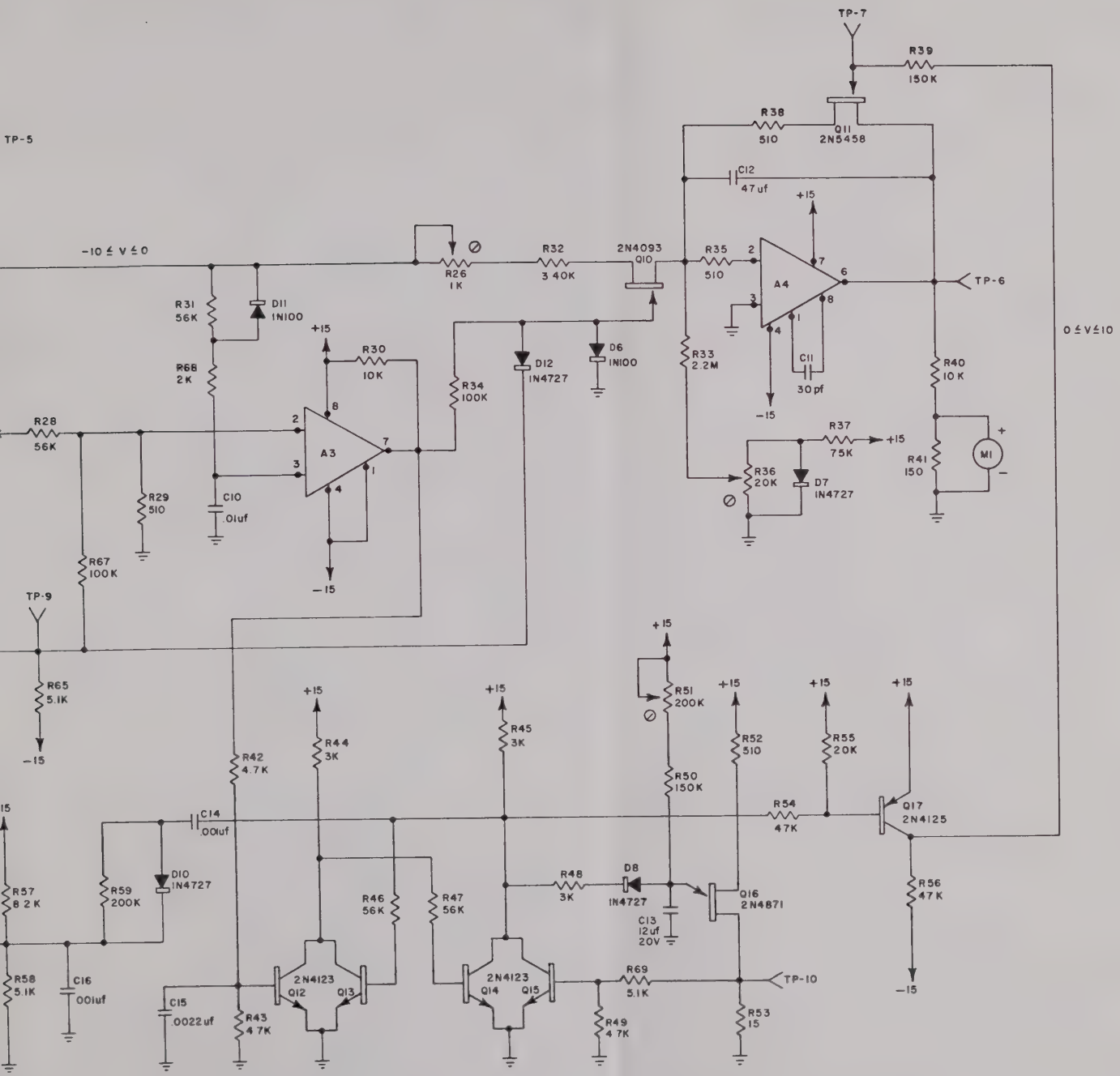
FIGURE 5.4 LOAD and ATTENUATORS



NOTE

(1) ALL RESISTORS WITH TWO DIGITS ARE ±5%, THREE DIGITS ±1%

[2] VALUES SHOWN ARE FOR MODEL 429 AND 429E. FOR MODEL 429A VALUES ARE, R76 = 3.74K, R77 = 2.32K AND R78 = 2.80K.



MAIN SCHEMATIC

FIGURE 5.5 MAIN SCHEMATIC

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section VI

REPLACEABLE PARTS

6.1 ■ INTRODUCTION

6.2 This section contains information for ordering replacement parts for the Model 429 Defibrillator Energy Meter.

6.3 Table 6-1 lists replaceable parts in alphanumerical order to their circuit symbols. Detailed information on a part used more than once in the instrument is listed opposite the first circuit symbol applying to the part. Other circuit symbols applying to the same part refer to the initial symbol. Detailed information includes the following:

1) Circuit symbol
2) Full description of part
3) Manufacturer of part
4) Manufacturer's part number
5) Total quantity used in the equipment

6.4 ■ ORDERING INFORMATION

6.5 Most of the parts listed in the parts list can be secured from local electronic part houses. If this is not feasible, or a part needs replacing that is not listed, address order or inquiry to:

CUSTOMER SERVICE
NEURODYNE-DEMPSEY, INC.
2505 OAK STREET
NAPA, CALIFORNIA 94558

Specify the following information for each part:

1) Model and complete serial number on instrument
2) Circuit symbol
3) Manufacturer of part
4) Manufacturer's part number
5) Description

6.6 To order a part not listed in Table 6-1, give a description of the part and include its function and location.

6.7 Table 6-1 are parts for Model 429. Table 6-2 are parts for Model 429A and Table 6-3 are parts for Model 429E which are different from Model 429.

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TABLE 6-1 REPLACEABLE PARTS FOR 429

REF SYM	DESCRIPTION		MFG	MFG NO	TQ
	Main PC Board Assembly		NDI	100168	1
	Load PC Board Assembly		NDI	100165	1
A1	Multiplier		Motorola	MC 1494L	1
A2	Op-Amp		N.S.C.	LM 301AN	2
A3	Voltage Comp.		N.S.C.	LM 311	1
A4	Same as A2				
C1	Not used				
C2	Not used				
C3	Capacitor Electrolytic	150 MFD 25V DC	Sprague	TE 1212	2
C4	Same as C3				
C5	Capacitor Tantalum	1 MFD 35V DC	Kemet	T310A105-035AS	4
C6	Same as C5				
C7	Same as C5				
C8	Same as C5				
C9	Capacitor Mica	30pf 500V DC	Elmenco	DM-15-300J	2
C10	Capacitor Mylar	0.01 MFD 80V DC	Sprague	192P-1039R8	1
C11	Same as C9				
C12	Capacitor Polycarbonate	0.47 MFD 100V DC	Amperex	C281CH/A470K	1
C13	Capacitor Tantalum	12 MFD 20V DC	Kemet	T310B126-020AS	1
C14	Capacitor Mylar	0.001 MFD 200V DC	Sprague	192P-10292	2
C15	Capacitor Mylar	0.022 MFD 200V DC	Sprague	192P-22292	1
C16	Same as C14				
C17	Capacitor Mylar	0.22 MFD 80V DC	Sprague	192P-2249R8	1
C18	Capacitor Mica	75pf 500V DC	Elmenco	DM-15-750J	1
C19	Capacitor Mica	300pf 500V DC	Elmenco	DM-15-301J	1
C20	Capacitor Mylar	4.7 nf 200V DC	Sprague	192P-47292	1
D1	Diode Bridge	1A 50V PIV	Motorola	MDA920A-2	2
D2	Same as D1				
D3	Diode Zener	IN821A		IN821A	1
D4	Diode Zener	IN961	Motorola	IN961	1
D5	Diode	IN4727		IN4727	6
D6	Diode	IN100		IN100	2
D7	Same as D5				

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TABLE 6-1 REPLACEABLE PARTS FOR 429 (continued)

REF SYM	DESCRIPTION		MFG	MFG NO	TQ
D8	Same as D5				
D9	Same as D5				
D10	Same as D5				
D11	Same as D6				
D12	Same as D5				
D13	Diode	IN5241B		IN5241B	2
D14	Same as D13				
F1	Fuse	1/2A 3AG			1
XF1	Fuse Holder		Littlefuse	342014	1
I1	Pilot Light	Neon	Eldema	CG03-RCS-N120	1
XI1	Pilot Light Socket		Eldema	DHO-10B-DI4B	1
J1	Coax Jack		Amphenol	UG-1094/V1050	1
K1	Knob		Raytheon	407D2K1	1
M1	Meter		NDI	1601-0001	1
Q1	Transistor	2N3053			2
Q2	Transistor	FET 2N5459			1
Q3	Transistor	MPS 6521			3
Q4	Same as Q3				
Q5	Same as Q1				
Q6	Transistor	2N4123			8
Q7	Same as Q6				
Q8	Same as Q6				
Q9	Not used				
Q10	Transistor	FET 2N4093			1
Q11	Transistor	FET 2N5458			1
Q12	Same as Q6				
Q13	Same as Q6				
Q14	Same as Q6				
Q15	Same as Q6				
Q16	Transistor	U.J.T. 2N4871			1
Q17	Transistor	2N4125			2
Q18	Same as Q6				
Q19	Same as Q3				

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TABLE 6-1 REPLACEABLE PARTS FOR 429 (continued)

REF SYM	DESCRIPTION		MFG	MFG NO	TQ
Q20	Same as Q17				
R1	Resistor Composition	33K ±5% 1/2W			1
R2	Resistor Composition	1K ±5% 1/4W			1
R3	Resistor Composition	1.5K ±5% 1/4W			1
R4	Resistor Composition	100K ±5% 1/4W			3
R5	Resistor Composition	150K ±5% 1/4W			3
R6	Resistor Composition	68K ±5% 1/4W			1
R7	Resistor Composition	4.3K ±5% 1/4W			1
R8	Resistor Variable	500Ω	Helipot	62PR-500	1
R9	Resistor Composition	3K ±5% 1/4W			5
R10	Resistor Composition	1.1K ±5% 1/4W			1
R11	Resistor Composition	33K ±5% 1/4W			1
R12	Resistor Composition	20K ±5% 1/4W			2
R13	Resistor Composition	18K ±5% 1/4W			1
R14	Resistor Metal Film	10.0K ±1% 1/8W	Corning	NA55-1002	2
R15	Same as R14				
R16	Resistor Composition	510Ω ±5% 1/4W			6
R17	Same as R16				
R18	Resistor Metal Film	30.1K ±1% 1/8W			1
R19	Resistor Metal Film	61.9K ±1% 1/8W			1
R20	Resistor Metal Film	16.2K ±1% 1/8W			1
R21	Resistor Metal Film	2.94K ±1% 1/8W	(factory selected)		2
R22	Same as R21				
R23	Resistor Variable	5K	Helipot	76PR 5K	2
R24	Same as R23				
R25	Resistor Variable	20K	Helipot	76PR 20K	1
R26	Resistor Variable	1K	Helipot	62PR 1K	1
R27	Resistor Metal Film	47.5K ±1% 1/8W			1
R28	Resistor Composition	56K ±5% 1/4W			4
R29	Same as R16				
R30	Resistor Composition	10K ±5% 1/4W			1
R31	Same as R28				
R32	Resistor Metal Film	3.40K ±1% 1/8W			1
R33	Resistor Composition	2.2M ±5% 1/4W			1

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TABLE 6-1 REPLACEABLE PARTS FOR 429 (continued)

REF SYM	DESCRIPTION		MFG	MFG NO	TQ
R34	Same as R4				
R35	Same as R16				
R36	Resistor Variable	20K	Helipot	62PR 20K	1
R37	Resistor Composition	75K ±5% 1/4W			1
R38	Same as R16				
R39	Same as R5				
R40	Resistor Metal Film	10.0K ±1% 1/8W			1
R41	Not used				
R42	Resistor Composition	4.7K ±5% 1/4W			3
R43	Same as R42				
R44	Same as R9				
R45	Same as R9				
R46	Same as R28				
R47	Same as R28				
R48	Same as R9				
R49	Same as R42				
R50	Same as R5				
R51	Resistor Variable	200K	Helipot	62PR 200K	1
R52	Same as R16				
R53	Resistor Composition	15Ω ±5% 1/4W			1
R54	Resistor Composition	47K ±5% 1/4W			2
R55	Same as R12				
R56	Same as R54				
R57	Resistor Composition	8.2K ±5% 1/4W			1
R58	Resistor Composition	5.1K ±5% 1/4W			3
R59	Resistor Composition	200K ±5% 1/4W			2
R60	Resistor Composition	16K ±5% 1/4W			1
R61	Same as R9				
R62	Resistor Composition	3.3K ±5% 1/4W			1
R63	Resistor Composition	13K ±5% 1/4W			1
R64	Resistor Composition	1.3K ±5% 1/4W			1
R65	Same as R58				
R66	Resistor Composition	270K ±5% 1/4W			1
R67	Same as R4				
R68	Resistor Composition	2K ±5% 1/4W			1

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TABLE 6-1 REPLACEABLE PARTS FOR 429 (continued)

REF SYM	DESCRIPTION	MFG	MFG NO	TQ
R69	Same as R58			
R70	Resistor Metal Film 178K ±1% 1/4W			2
R71	Resistor Metal Film 158K ±1% 1/4W			4
R72	Same as R71			
R73	Same as R71			
R74	Same as R71			
R75	Same as R70			
R76	Resistor Metal Film 3.65K ±1% 1/4W			1
R77	Resistor Metal Film 3.16K ±1% 1/4W			2
R78	Same as R77			
R79	Resistor Composition 200K ±5% 1/2W			5
R80	Same as R79			
R81	Same as R79			
R82	Same as R79			
R83	Same as R79			
R84	Resistor Metal Film 1.02K ±1% 1/8W			1
R85	Resistor Composition 5.6K ±5% 1W			5
R86	Same as R85			
R87	Same as R85			
R88	Same as R85			
R89	Same as R85			
R90	Not used			
S1	Power Switch	Alconswitch	MST105D	1
S2	Range Switch	NDI	2501-0002	1
T1	Power Transformer	NDI	1201-0002	1

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TABLE 6-2 REPLACEABLE PARTS FOR 429A

REF SYM	DESCRIPTION	MFG	MFG NO	TQ
	Main PC Board Assembly	NDI	100863	1
	Load PC Board Assembly	NDI	100864	1
M1	Meter	NDI	1601-0004	1
R70	Resistor Metal Film 174K ±1% 1/4W			2
R75	Same as R70			
R76	Resistor Metal Film 3.74K ±1% 1/4W			1
R77	Resistor Metal Film 2.32K ±1% 1/4W			1
R78	Resistor Metal Film 2.80K ±1% 1/4W			1
T1	Transformer Power	NDI	1201-0003	1

TABLE 6-3 REPLACEABLE PARTS FOR 429E

REF SYM	DESCRIPTION	MFG	MFG NO	TQ
T1	Transformer Power	NDI	1201-0003	1

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ABBREVIATIONS AND SYMBOLS

A & amp	= Ampere (s)	M	= Mega 10^6
AC	= Alternating Current	nf	= Nanofarad 10^9
C	= Capacitor	pf	= Picofarad
D	= Diode	R	= Resistor
db	= Decibels	Ref.	= Reference
DC	= Direct Current	RF	= Radio Frequency
div	= Division	S	= Switch
DVM	= Digital Voltmeter	Sym.	= Symbol
°	= Degrees	T	= Transformer
°C	= Degrees Centigrade	TP	= Test Point
F	= Fuse	TQ	= Total Quantity
Hz	= Hertz	V	= Volt
J	= Jack	W	= Watt
K	= Kilo 1000	ws	= Watt-second
m	= Milli 1/1000	μ	= Micro 10^6
ma	= Milliampere	μf	= Microfarad
ms	= Millisecond	Ω	= Ohm
mv	= Millivolt		

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WARRANTY

The terms and conditions of warranties made by Neurodyne-Dempsey, Inc. with respect to its products are as set forth in its Standard Terms and Conditions of Sale which are included herein by reference. Pursuant to those provisions, Neurodyne-Dempsey Inc. warrants that all products are to be free from defects in workmanship and materials for a period of one year, unless a different period is specified, after delivery to customer. If notice of defect is timely given, Neurodyne-Dempsey will either modify the product or part to correct defect, replace the product or part with either new or factory reconditioned complying products, or parts, or refund the amount paid for the defective part. The Standard Terms and Conditions of Sale are printed on the reverse side of the company's invoice and acknowledgement of customer's order forms, and additional copies thereof may also be obtained from the company's offices.

DEFIBRILLATOR PERFORMANCE INSPECTION

DATE	
HOSPITAL	AREA LOCATION
PERSON PERFORMING TESTS	
INSTRUMENT MANUFACTURE	MODEL
SERIAL NUMBER	

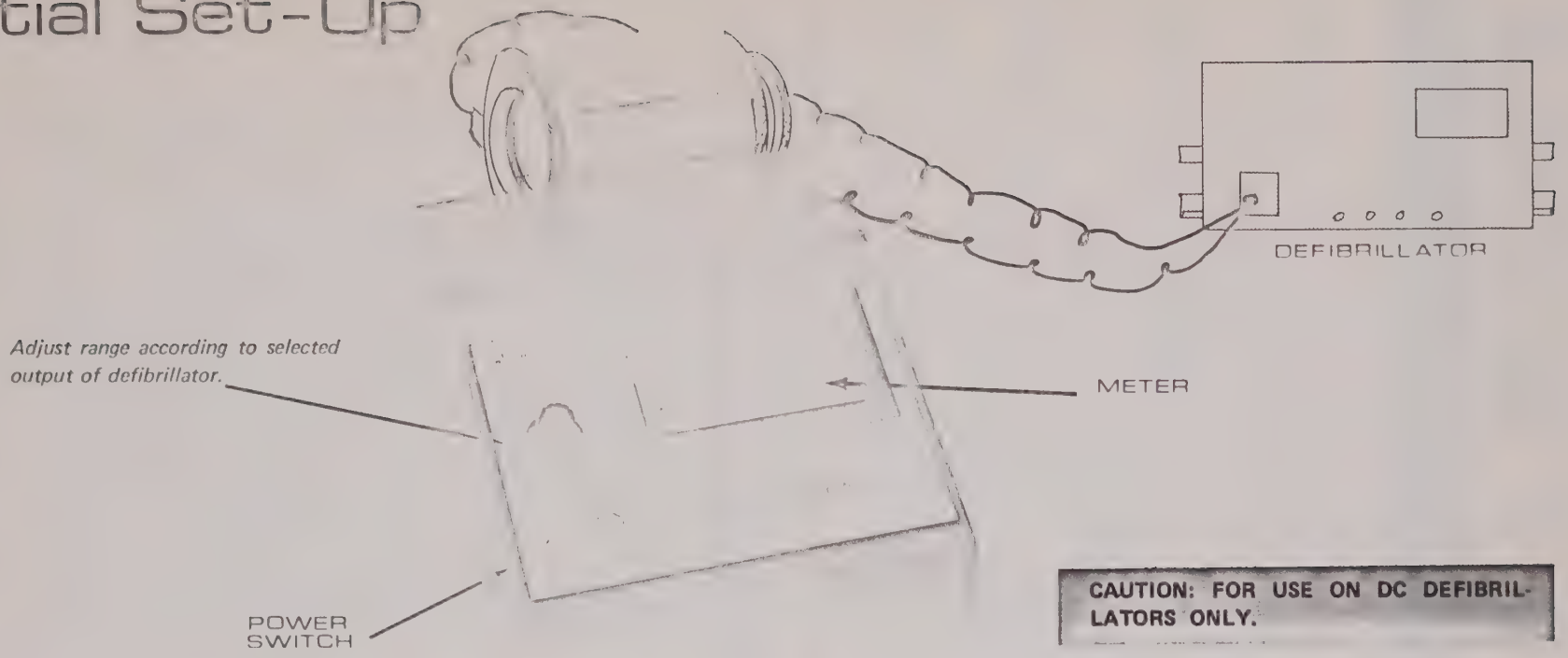
METER or DIAL SETTING (W-S)	DELIVERED ENERGY (WATT SECONDS)						COMMENTS
	DATE	DATE	DATE	DATE	DATE	DATE	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	
	W-S	W-S	W-S	W-S	W-S	W-S	

Instructions on reverse side of sheet.

Special Services Operation of
Neurodyne-Dempsey, Inc. 250[illegible] Oak St., Napa, CA 94558 – (707) [illegible]-6767

Form 429-SS-1
Copyright 1973 Neurodyne-Dempsey
Printed in U.S.

Initial Set-Up



CAUTION: FOR USE ON DC DEFIBRILLATORS ONLY.

DEFIBRILLATOR ENERGY METER, MODEL 429

INSTRUCTIONS:

FIRST
Plug the Model 429 into appropriate AC outlet and turn power on.

SECOND
Use range control to select range for best accuracy.

THIRD
Set-up and energize defibrillator according to manufacturer's instructions.

USE CAUTION IN HANDLING PADDLES

FOURTH
Place defibrillator paddles on ends of load and press firmly.

NOTE: DO NOT USE ELECTRODE PASTE

FIFTH
Discharge defibrillator and read delivered energy on meter. Meter will hold reading for approximately 5 seconds.

SIXTH
Record reading on reverse side and on calibration tag on defibrillator.

SEVENTH
Repeat test for each desired setting of the defibrillator.

NOTE:
MOST DEFIBRILLATORS ARE CALIBRATED IN STORED ENERGY. THIS METER READS DELIVERED ENERGY TO A SIMULATED PATIENT. THE READINGS AS MEASURED MAY BE CONSIDERABLY LOWER THAN THE NUMBER INDICATED ON THE DEFIBRILLATOR.

DAMAGE & SHORTAGE

Before you fully unpack any unit READ THIS for your protection

(THIS INFORMATION APPLIES ONLY ON SHIPMENTS WITHIN THE UNITED STATES)

DAMAGE This shipment was packaged and delivered to the carrier with the utmost care to insure safe delivery of goods. When shipment is received and signed for by the transportation company, consignor's responsibility ceases. Do not accept shipment which evidences damage or shortage until agent of carrier endorses a statement of the irregularity on the face of the transportation receipt. Without documentary evidence, claim cannot be filed.

CONCEALED DAMAGE Interstate Commerce Commission has indicated that a carrier is as much responsible for concealed damage as for visible damage in transit. Upon receipt of shipment, promptly unpack and check thoroughly. If concealed damage is discovered, cease further unpacking and request immediate inspection by local agent of carrier. A written report of the agent's findings, with his signature, is necessary to support claim.

SHORTAGE Check shipment against shipping papers. Do not discard packing materials or packing cases until contents have been found to be correct. The removal of badly needed items, before shipment has been checked, may create a shortage. Check all possibilities before reporting a shortage.

CLAIMS If your agent or carrier has been given an opportunity to inspect the shipment, any claim for a shortage or damaged merchandise can be handled as a simple and routine procedure. Claims must be filed by consignee. Shipping terms are f.o.b. Napa, California.

LOSS In the event of complete loss, claim will be handled in the same manner as for Shipping Damage or Shortage.

**Note further information below.*

SHIPPING DAMAGE OR SHORTAGE

AIR FREIGHT — Claim must be initiated at point of destination. Claim must be filed by submitting a letter on company stationery with an explanation of the extent of damage or loss and forwarded with a copy of the original* air bill, and original invoice or photostat of same, to the airline having carried the shipment.

*Upon request certified photostatic copies of original papers held by Neurodyne-Dempsey, Inc. required in support of claims will be made available.

PARCEL POST / UPS

PLACING CLAIM FOR DAMAGE — For those shipments insured by Parcel Post, the addressee initiates the claim by filling out Post Office Dept. Form 3812, "Request for Payment of Domestic Postal Insurance". Item 12 is to be other than Neurodyne-Dempsey, Inc. Damaged material must be returned to the Post Office of address for inspection. A new purchase order is required by Neurodyne-Dempsey, Inc. to cover the cost of repairs (or in the case of loss or refiling-replacement order). Damaged material will be repaired and returned. Party named in item 12 of form 3812 will receive reimbursement for repair cost from Post Office Department.

PLACING CLAIM FOR LOSS — In the event of a report to consignor of loss or refiling, Post Office Dept. Form 3812 will be initiated by Neurodyne-Dempsey, Inc. at point of origin. If, after Post Office investigation, the material is not located, disposition from this point will be the same as stated in the above paragraph—"Placing claim for damage."

PLACING CLAIM FOR DAMAGE TO SHIPMENTS BY UNITED PARCEL—The addressee must notify Neurodyne-Dempsey, Inc. who will notify United Parcel Service giving the shipper's number and date parcel was shipped. United Parcel Service will send a representative to inspect the damage and advise proper disposition. A new purchase order is required by Neurodyne-Dempsey Inc. to cover the cost of repairs or in the case of loss or refiling, a replacement order. Damaged material will be repaired and returned.

DATA SHEET 1003-10/73

NEURODYNE-DEMPSEY, INC.
2595 OAK STREET, NAPA, CALIFORNIA 94558 (707) 255-6767

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CUSTOMER SERVICE BULLETIN

STORED ENERGY VERSUS DELIVERED ENERGY TO VARIOUS LOADS

In the past, defibrillator manufacturers have calibrated their instruments in terms of stored energy because of the ease of measuring this quantity. The energy stored on a capacitor is given by:

$$W = \frac{1}{2} C V^2$$

where W is the energy in watt-seconds, C is the capacitance in farads, and V is the voltage on the capacitor.

Thus, to measure the stored energy all that was required was a voltmeter which was then calibrated in terms of energy. The energy that is delivered to an external load upon discharge of a defibrillator is dependent upon the value of the load resistance and the internal resistance of the defibrillator.

The defibrillator and load can be represented by the simplified circuit shown in the Figure 1. Using this circuit, it can be shown that:

$$\frac{W_L}{W_T} = \frac{R_L}{R_I \quad R_L}$$

where W_L is the energy dissipated in the load, W_T is the total energy. R_I is the internal resistance and R_L is the resistance of the load.

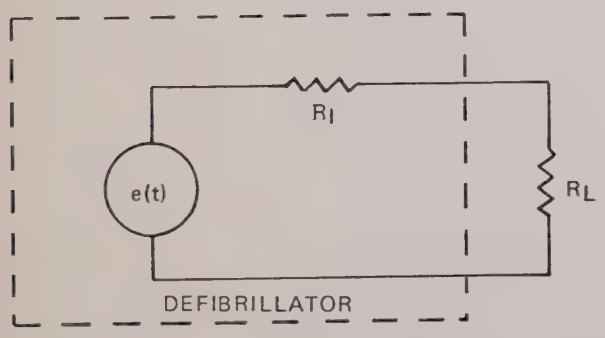

Figure 1. Simplified Schematic of Defibrillator and Load

In the past, there had not been a standard adopted to what the load resistance should be when referring to the delivered energy. It has been generally established that a good estimation of the trans-thorax impedance during defibrillation is 50 ohms. This value has now been established as a standard load for measuring the output of a defibrillator.

Most defibrillators will deliver between 60 and 80 percent of the stored energy to a 50 ohm load. With the Model 429, the energy delivered to a 50 ohm load can be measured with good accuracy and from this, the internal resistance of the defibrillator can be calculated using the following formula:

$$R_I = R_L\left(\frac{W_S}{W_L} - 1\right)$$

where W_S is the energy stored on the capacitor. W_L is the energy measured with the Model 429 and R_L is 50 ohms, the resistance of the load on the Model 429.

Once the internal resistance of the defibrillator is known, the energy that would be delivered to another load can be computed using:

$$W_X = W_S \frac{R_X}{R_I + R_X}$$

where W_X is the energy delivered to a load having a resistance of R_X.

Example: For a given defibrillator, it is found that when the meter on the defibrillator indicated 200 ws of stored energy, the Model 429 measures 130 ws delivered to the 50 ohm load. How much energy would be delivered to a 75 ohm load and a 100 ohm load for the same stored energy?

$$R_I = 50\left(\frac{200}{130} - 1\right)$$

$R_I = 26.9$ ohm

APPENDIX

therefore, the energy delivered to a 75 ohm load would be:

$$W_{75} = 200\left(\frac{75}{26.9 + 75}\right)$$

$$W_{75} = 147.2 \text{ ws}$$

the energy delivered to a 100 ohm load would be:

$$W_{100} = 200\left(\frac{100}{26.9 + 100}\right)$$

$$W_{100} = 157.6 \text{ ws}$$